(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 512 745 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **92303878.0**

(51) Int. Cl.^{5} : **B60C 23/00**

(22) Date of filing : **29.04.92**

(30) Priority : **02.05.91 GB 9109466**

(43) Date of publication of application :
11.11.92 Bulletin 92/46

(84) Designated Contracting States :
DE FR GB IT

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(54) A method of detecting a deflated tyre on a vehicle.

(57) A method of detecting a partially deflated tyre on a vehicle having four tyres each mounted on a wheel (1,2,3,4) provided at each wheel with a signal generator producing a series of digital signals or pulses (1',2',3',4) spaced apart by equal increments of angular rotation of the respective tyre and wheel assembly characterised by calculating from one of the series of signals the vehicle speed, selecting an appropriate interval for deflation detection, measuring for each of the four wheels a speed of rotation signal for said interval, storing the speeds found, repeating the measuring for at least three consecutive successive equal chosen intervals, averaging the speeds to produce an average speed signal for each wheel, processing the four signals in a processing unit (8) which subtracts the sum of the signals from one pair of diagonally opposite wheels from the sum of the signals from the other pair of diagonally opposite wheels, sensing when the magnitude of the result is between 0.05% and 0.6% of the mean of the two sums and when it is, operating a warning device to indicate a tyre is partially or completely deflated.

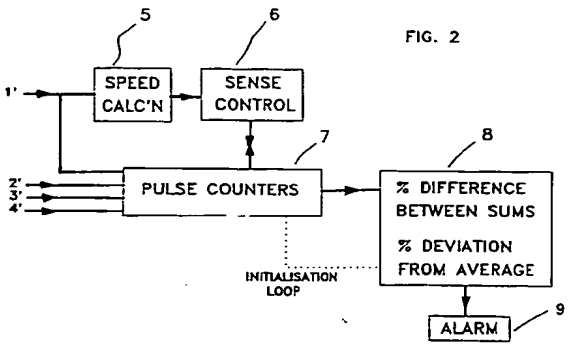

FIG. 2

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This invention relates to a method of detecting a deflated tyre on a vehicle and provides a system suitable for cars and trucks and the like.

European patent publication No. 291217 describes a system primarily aimed at vehicles having electronic anti-lock braking systems although it may be used as a stand alone system.

Two versions are disclosed one of which uses a multi pulse signal generating means at each wheel. The other is a single pulse per wheel revolution generator. Further details of these systems are disclosed in the publications for our co-pending European patent Applications No. 91300939.9 and 91300938.7 both dated 5th February 1991.

The multi pulse signal based unit of the above systems have been found to have a minimum speed above which the system operates satisfactorily of about 10km/h when a wheel speed generator of 96 teeth is used. In the case of a 48 tooth generator the minimum speed is of the order of 18 Km/h. Thus there is a limitation at low speeds for the multi pulse system. By contrast a single pulse per revolution system which is also described in the earlier applications, and which is based on the time per revolution, has been found to be very good at low speeds but at high speeds, where the time periods to be measured are very short, it is necessary to use comparatively expensive computer systems and thus the system is not very efficient cost wise.

An object of the present invention is to provide in a tyre a deflation warning system of the above type, a means of avoiding the above speed induced limitations and to give a wide effective speed range to the device, at minimum cost.

According to the present invention a method of detecting a partially deflated tyre on a vehicle having four tyres each mounted on a wheel, provided at each wheel with a signal generator producing a series of digital signals or pulses spaced apart by equal increments of angular rotation of the respective tyre and wheel assembly comprises calculating from one of the series of signals the vehicle speed, selecting an appropriate interval for deflation detection, measuring for each of the four wheels a speed of rotation signal for said interval, storing the speed signal found, repeating the measuring for at least three consecutive equal chosen intervals, averaging the speeds to produce an average speed signal for each wheel, processing the four signals in a processing unit which subtracts the sum of the signals from one pair of diagonally opposite wheels from the sum of the signals from the other pair of diagonally opposite wheels, sensing when the magnitude of the result is between 0.05% and 0.6% of the mean of the two sums and when it is, operating a warning device to indicate a tyre is partially or completely deflated.

Further aspects of the present invention will become apparent from the following description of an embodiment of the invention by way of example and in conjunction with the attached diagrammatical drawings in which Figure 1 shows the four wheel positions on a vehicle and Figure 2 is a block diagram of the calculation elements.

As can be seen the vehicle has four wheels, the front wheels being No's 1 and 2 and the rear wheels No's 3 and 4. each wheel is provided with a multi tooth pulse generator of the same type as used on electronic ABS equipped vehicles. Suitable generators produce 96 pulses for each revolution of the wheel. The four output chains of pulses 1',2',3',4' are fed into a car mounted computer illustrated in Figure 2. Firstly the output signal 1' from the front left hand wheel, is fed into a speed calculating unit 5 where the speed of the vehicle is calculated. The resultant speed is then fed to a sense control unit 6.

The sense control unit 6 determines from a premapped set of characteristics, a suitable appropriate interval for measuring the speed of the vehicle wheels and carrying out the desired deflation sensing check. In the preferred arrangement this interval is a number of pulses. For example 128 pulses at low speeds typically 4-15 km/h 768 pulses at 20 to 95 km/h or 2048 pulses at 50 to 260 km/h. This gives time periods of 0.5 to 2.5 secs for sensing.

Thus having chosen the number of pulses for which measurements will be carried out the sense control unit 6 operates taking output signals from each wheel and processing them in timing units. Four separate timing units are provided in the pulse counting unit 7 one of each of the speed input signals 1',2',3',4' and these log the time from each wheel. As will be appreciated each time for each wheel is directly proportional to the speed of the respective wheel, and these signals are then used to determine whether or not there is a relative deflation on one or more of the tyres of the vehicle.

The important feature of the present invention is that for different vehicle speeds as measured by the speed calculating unit 5 operating on the speed signal 1' from the front left hand wheel No. 1, the sense control unit 6 determines a different number of pulses within which the time will be measured for the four wheels. This allows the system to have good accuracy by choosing the number of pulses to use to provide the necessary accuracy in the calculated wheel speeds to sense a small change in radius as is caused by a small deflation of the tyre (for example .6 bar).

The processing of the four speeds signals which come from the pulse counter unit 7 is basically the same as that in the prior applications in that the processing unit 8 calculates factors for the lateral and longitudinal acceleration of the vehicle by comparing the angular velocity signals for the wheels on each side of the vehicle, and then comparing the signals from the front and rear pair of wheels with the forward speed calculated from the mean of the angular veloc-

ities of all four wheels. The lateral and longitudinal acceleration factors which may be accelerations or other acceleration dependent factors, are compared with a predetermined value for the vehicle concerned. If an excessive longitudinal acceleration factor is found then the deflation warning calculated is inhibited. If a lateral acceleration greater than ≈0.06g is sensed then once again sensing of a deflation warning is inhibited. These are to avoid false deflation warning signals due to weight transfer and tracking effects caused by a high vehicle lateral and longitudinal accelerations, because such signals cause similar changes in rolling radius to a deflation.

The system then calculates an error signal dT by comparing the times (which are proportional to the angular velocities) for the wheels according to the formula:-

$$dT = \frac{2x\,(F14 - F23)x\,100}{F14 + F23}$$

where

$$F14 = F1 + F4 \quad F23 = F2 + F3$$

and F1, F2, F3, F4 are the times for the number of wheel pulses chosen.

This dT signal is monitored and the processing unit prepares to sense of deflation if the signal is greater than 0.05% and less than 0.6%. If such a signal is found then the existence of a puncture is known and the next step is to find out which tyre is punctured.

The monitoring unit 8 then calculates the difference between each wheel speed in turn and the average speed of the four wheels, and if the difference between any one wheel and the average is more than 0.1%, a second signal is generated.

If both dT and the different signals exist in the ranges mentioned, then a deflation is sensed and the wheel concerned determined. An output signal is then given to the alarm 9 which is conveniently a light on the dashboard of the vehicle to show the deflation and four other lights to show which wheel has the deflation.

As a safety guard against spurious signals the warning signal is preferable delayed until 3 or more consecutive warning results have been obtained in the processing unit 8.

To fully allow for a tyre and vehicle characteristics it is necessary to trigger manually or otherwise a calibration initiating signal. This is done after changing one or more tyres of the vehicle and when the vehicle is new, and may in some circumstances be necessary after reflation although this is not usual.

As an alternative to the time measuring system which operates as described above the system may select from the calculated vehicle speed a suitable time interval and then for each of the four wheels count the number of pulses and then process these and signals in the same way.

Claims

1. A method of detecting a partially deflated tyre on a vehicle having four tyres each mounted on a wheel (1,2,3,4), provided at each wheel with a signal generator producing a series of digital signals or pulses (1',2',3',4') spaced apart by equal increments of angular rotation of the respective tyre and wheel assembly characterised by calculating from one of the series of signals the vehicle speed, selecting an appropriate interval for deflation detection, measuring for each of the four wheels a speed of rotation signal for said interval, storing the speeds found, repeating the measuring for at least three consecutive successive equal chosen intervals, averaging the speeds to produce an average speed signal for each wheel, processing the four signals in a processing unit (8) which subtracts the sum of the signals from one pair of diagonally opposite wheels from the sum of the signals from the other pair of diagonally opposite wheels, sensing when the magnitude of the result is between 0.05% and 0.6% of the mean of the two sums and when it is, operating a warning device to indicate a tyre is partially or completely deflated.

2. A method according to claim 1 characterised in that the appropriate interval comprises a unit of time and the speed of rotation signals (1',2',3',4') for the four wheels are measured by counting the number of pulses in said chosen unit of time.

3. A method according to claim 1 characterised in that the appropriate interval comprises a number of pulses and the speed of rotation signals (1',2',3',4') for the four wheels each comprise the measured time interval for said number of pulses.

4. A method according to claim 3 characterised in that following the selection of the appropriate interval, the times for each of the four wheels begin at the first pulse thereafter for the wheel concerned.

5. A method according to claim 3 or 4 characterised in that the number of pulses chosen are substantially a whole number of rotations of a wheel.

6. A method according to any one of claims 1 to 5 characterised in that the calculation of vehicle speed is repeated whilst the speeds of rotation (1',2',3',4') of the four wheels are being measured so that a second monitoring and calculation may immediately follow the first.

7. A method according to any one of claims 1 to 6 characterised in that the processing unit also

compares the speed of rotation each of the four wheels (1',2',3',4') in turn with the average of all four signals and senses when said values differ by more than 0.1% and signals a deflation when both this signal; and the previously mentioned signal factor are in the ranges specified.

8. A method according to any one of claims 1 to 7 characterised in that the times are measured against a separate clock frequency for each wheel.

9. A method according to any one of claims 1 to 8 characterised in that when the processing unit repeats the deflation sensing operation and operates the warning device when at least two successive results each jive an indication of a tyre subject to pressure loss.

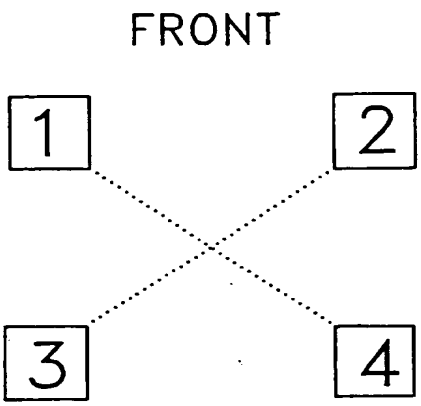

FIG. 1

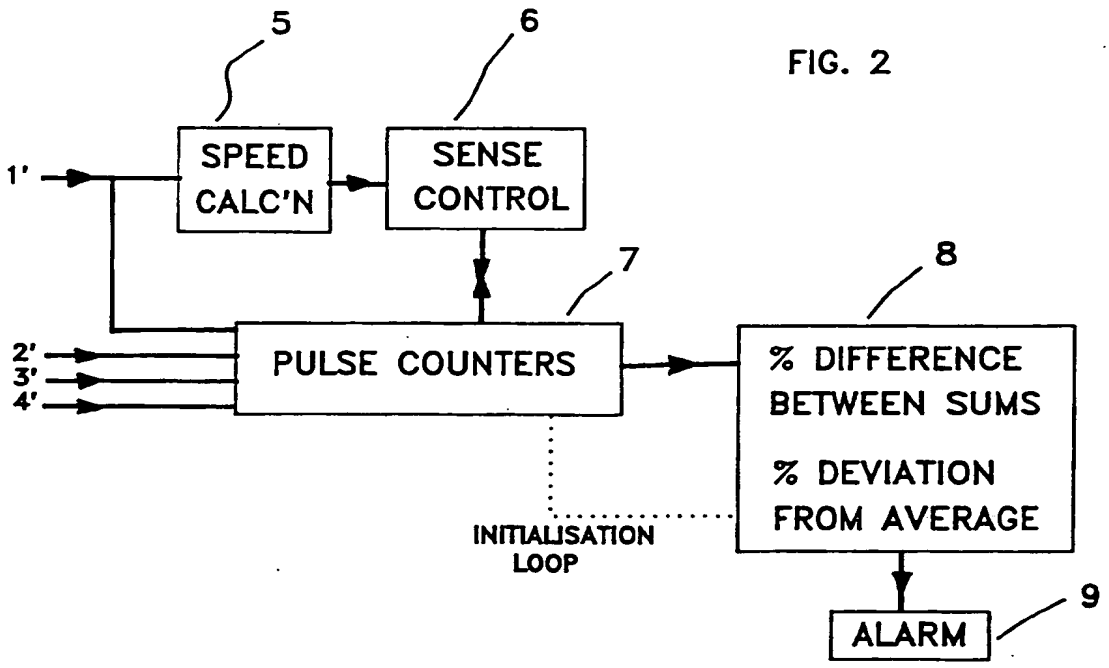

FIG. 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 30 3878

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
P,D, A	EP-A-0 441 599 (SUMITOMI) * column 4, last paragraph - column 5, paragraph 1 *	1-9	B60C23/00
D,A	EP-A-0 291 217 (SP TYRES UK LTD.) * the whole document *	1-9	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			B60C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 JULY 1992	HAGEMAN M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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